

Factor I – Research Assignment

A. Research Organization

The incumbent is a Senior Research Engineer assigned to the Evaluation Methods Branch (EMB) of the Base Competency (BC). EMB plays a strategic critical role in aerospace by pioneering nondestructive evaluation (NDE) and integrated vehicle health management (IVHM) technologies, advancing the fundamental science bases for these technologies, and transferring these advancements for application within the Agency, to other Government agencies, to aerospace industries and the academic community.

B. Personal Research

The incumbent is responsible for formulating and conducting research to advance IVHM technologies for application to aerospace structures, as well as leading a group of NASA, university, and contractor personnel to develop innovative solutions to IVHM problems. IVHM has been identified as a critical and enabling technology for meeting Agency goals for the increased safety and reliability, and reduced operating cost of future generation Reusable Launch Vehicles (RLV's) as well as for future generations of aircraft. IVHM is also being investigated for retrofit to the current aging fleets of commercial and military aircraft. The incumbent seeks solutions to research problems of critical importance and of fundamental interest to industry and government agencies in ultrasonic, acoustic emission, and fiber-optic sensing science. These problems are of a nature that they are critical to the Agency's mission and of such difficulty that they require basic research and development. The incumbent develops new hypotheses, concepts, and techniques to formulate and attack these problems. The incumbent's technical leadership in this area is recognized by academia, industry and other government agencies as evidenced by his recent appointment as Scientific Editor of *Structural Health Monitoring: An International Journal*, his recent publication of a chapter on acoustic emission methods in the *Nondestructive Evaluation: Theory, Techniques, and Applications* textbook, and his numerous collaborations, consultations, and invited presentations to universities, industries and other government laboratories. Of particular note in this respect are invited presentations given by the incumbent at the prestigious Gordon Research Conference, the Max Planck Institute for Materials Research in Munich Germany, and at two National Science Foundation Special Symposia, as well as invited Short Course Lectures for the Acoustic Emission Working Group Conference. Technology transfer from the incumbent's technical output is facilitated by writing technical papers and presenting research results at major international conferences, and by direct collaboration with industrial partners.

C. Team Leadership

IVHM for structural systems is inherently multi-disciplinary, involving the coordination and integration of the development of sensors, measurement systems, advanced data systems architectures, and structural analysis methodologies. To successfully lead in this field, the incumbent coordinates research and development efforts across multiple branches, competencies, NASA centers, industry, universities, and other government agencies. Further, as IVHM technologies are being developed in support of multiple programs including Aerospace Vehicle Systems Technology (AVST), Space Launch Initiative (SLI), Advanced Space Transportation Program (ASTP), and Aviation Safety (AvSP), the incumbent serves as team lead for multiple projects. The incumbent has a broad technical competence or knowledge of piezoelectric, fiber-optic, and other advanced sensing systems, data acquisition and measurement system technology, theory of mechanical deformation and elastic wave propagation in solids, analytical and numerical techniques for modeling sensing phenomena, and properties of materials to include both isotropic metals and anisotropic, inhomogeneous composites.

In support of the AVST program, the incumbent leads the IVHM project of the Robust Aerospace Vehicle element in the development of technology that is critical to the achievement of the program's "Eagle" vision future generation aerospace vehicle. Such a biologically inspired vehicle concept will require the integration of enormous numbers of IVHM sensors for control of structural configuration and actuators, damage detection, etc. The incumbent is leading a team to develop embedded, multi-functional, distributed sensor systems for the measurement of strain, temperature, vibration, acoustic emission, chemistry, and other important structural variables. Within LaRC, the team includes approximately 15 civil servants in GS grades 11-15 from five different Branches and three different Competencies. In addition, the team includes contractors on-site, as well as a number of university professors and industry researchers external to NASA. As Team Leader, the incumbent coordinates the technical aspects of all research activities and provides technical consultations, advice, and mentorship to Team researchers. The incumbent prepares materials and reports on research activities and accomplishments, and prepares and presents advocacy materials.

In a similar role for the SLI, also known as the 2nd Generation RLV Program, the incumbent is leading a team to increase the technology readiness level (TRL) of advanced IVHM sensor technology for application on the next generation RLV. This effort has a much more near term focus and is directed primarily toward the utilization of distributed, Bragg grating, fiber-optic sensors for high density strain and temperature measurement on composite cryotank structures. In addition to characterizing the performance and reliability of these sensor systems, the team is developing sensor attachment methodologies to survive the extreme thermal environment from cryogenic temperatures to elevated re-entry temperatures. Approximately 8 civil servants, in GS Grades 11-15 from two Branches participate on this team, along with several contractors. This is a coordinated effort with both Northrop Grumman and North Carolina State University under two NRA task agreements.

The incumbent leads much smaller teams to support the ASTP and AvSP IVHM development efforts. For the former program, the incumbent leads a team consisting of members from both LaRC and NASA Dryden to develop high temperature, multi-parameter fiber-optic sensors. For the AvSP, the incumbent leads a small LaRC team to investigate the applicability of fiber-optic and acoustic emission sensors for damage detection in structures representative of the existing aircraft fleet. The goal of this project is to develop sensing systems and analysis algorithms that can be retrofitted to the current commercial and military aging aircraft fleet that will lead to significantly increased safety and reduced operating costs.

D. Related Functions

As a focal point for IVHM of structures, the incumbent represents LaRC on an Agency-wide team tasked with the coordination and integration of IVHM subsystem (i.e., structures, propulsion, thermal protection systems (TPS), avionics, etc.) development efforts. In addition, the incumbent was the inaugural Co-chair and host for the organizational meeting of the Agency wide Sensors Working Group (SWG), and continues to serve as LaRC's representative for the SWG. The incumbent also serves in a review role during NASA programmatic planning activities, and also for the evaluation of other NASA proposals such as unsolicited grant proposals, small business innovative research proposals, etc. Because of his recognized expertise in the field of IVHM, the incumbent is also often asked to serve in review and advisory roles for other government agencies including the Department of Defense and the Department of Commerce. In addition, the incumbent serves on and/or chairs EMB Technical Paper review committees.

E. Administrative Responsibilities

Administrative responsibilities include developing and managing research Task Agreements (TA's) and Memorandums of Agreement (MOA's), as well as serving as Technical Monitor and COTR

for Contracts and Research Grants. The incumbent is responsible for ensuring that funds associated with TA's are committed, obligated, and costed according to Center and Agency policy and metrics.

Factor II, Supervision Received.

A. Supervisory Relationship

The incumbent's immediate supervisors are Dr. Gerald Edmunds, Branch Head, and Rachel Madison, Asst. Branch Head. As the incumbent is recognized as an international authority and distinguished scientist in his field of expertise, his supervisory guidance reflects this leadership role. The incumbent receives only broad administrative supervision, which is primarily limited to staffing. Technical supervision is nominal and consultative. The incumbent develops research approaches and plans, advocating programmatic efforts, and leads the research efforts to their completion. The incumbent is responsible for all technical aspects of the research, authoritatively interpreting findings, and the applicability of findings to Program and Agency interests.

B. Required Approvals

The incumbent has considerable latitude to make decisions and sets the course of research activities not only in his branch, but significantly influences the research direction Agency wide. Actions of the incumbent that require approval by others are primarily limited to issues and strategies related to Center or Agency policies, and those resulting from changes in research scope, project funding, or staffing. Within the framework of Agency program objectives, priorities, and pressures for results, the incumbent formulates the plans and approaches for the solution of problems, taking full technical responsibility for these activities.

C. Delegated Authority

The incumbent is recognized as the technical authority in the described areas of responsibility, and makes recommendations at the Agency level concerning technical matters fundamental to establishing and achieving program goals. The recommendations are usually accepted and acted upon by Agency level managers. The incumbent continuously evaluates the technical performance of industry and government organizations involved in meeting program objectives, and represents NASA programs to senior members of the scientific and technical community through presentations to professional groups, industrial customers and national advisory groups. In addition, the incumbent keeps his supervisors informed of such outside interactions. He has broad delegated authority and can advocate for and commit to new work in his area of expertise. He has authority to make recommendations and commitments both to other Langley and NASA organizations

Factor III, Guidelines and Originality.

A. Existing Knowledge

Current exiting knowledge for the development of IVHM technologies for aerospace structures is very limited, and for many types of problems, it is nonexistent. There are significant gaps in the existing literature with respect to the development, modeling, characterization, and application of such advanced IVHM sensor technologies as acoustic emission and fiber-optics, particularly with respect to applications on complex composite aerospace structures. Present knowledge does not provide useful guidance for the types of problems NASA requires to be addressed. The knowledge and experience of the incumbent in these research areas is critical for the success and fruitfulness of the research effort, the accomplishment of technical milestones, and the achievement of Program goals.

B. Originality Required

The incumbent exhibits a very high degree of ingenuity and innovation in planning and leading research efforts for which there is little existing guidance and literature, or for which there are significant gaps in existing literature and methodologies. The assigned research described in Factor I spans the entire research and development process from problem definition and formulation, approach development, implementation of theoretical and empirical methods and techniques, to laboratory experimentation and field application. The incumbent applies an extremely high degree of originality to his work in advanced IVHM sensor technologies.

C. Demonstrated Originality

The incumbent has demonstrated originality in numerous research efforts that have had significant impact at the national and international level. Most notable was the incumbent's research on waveform based analysis methodologies and modeling techniques for acoustic emission IVHM sensing, which has led to the new field of "Modal AE". As a result of this new field, a new small business (Digital Wave Corporation) was formed, which has had multi-million dollars/year revenues in instrumentation sales and in successfully applying Modal AE techniques to solve both aerospace and nonaerospace IVHM problems. Additionally, nearly all other AE companies in the US and Europe have developed Modal AE analysis packages and training programs. The incumbent has also generated six invention disclosures, resulting in three granted patents with one patent pending. The most recent invention disclosure is for an entirely new sensor technology known as sensory alloys in which microstructural constituents within a metallic or polymer system function as sensor elements. Thus, the structural material itself becomes a sensor array that records, in-situ, important structural parameters such as peak strain. Such a technology has the potential for completely revolutionizing the field of IVHM for structural applications. Another patent pending is the development of multiplexing technology for AE sensing. Prototypes of this technology have been successfully fabricated and tested, and the technology will enable the application of AE to aerospace vehicles at dramatically reduced cost, along with significant reductions in weight and power requirements. Commercial AE and major aerospace companies have expressed considerable interest in this technology. The incumbent also received a patent for a method for determining the angle of impact on a structure, which is an important parameter for damage assessment. This invention, along with additional research that demonstrated the capability of Modal AE for assessing the degree of penetration for hypervelocity impacts, has important implications for assessing damage from impact events from sources such as micrometeoroid and orbital debris on spacecraft. NASA JSC has ongoing discussions with LaRC on the development and application of AE techniques to detect and assess impacts and/or leaks on the International Space Station. The SLI program has also expressed interest in evaluating AE for application to impact detection on future RLV's.

Factor IV, Qualifications and Scientific Contributions.

The incumbent has demonstrated outstanding accomplishments in the field of IVHM of structural systems and is recognized as an international authority in the field. He is the Scientific Editor of *Structural Health Monitoring: An International Journal*, responsible for the quality of the peer review publication process, which is carried out through more than 35 Associate Editors in the US, Canada, Europe, Asia, and Australia. He has authored a number of publications, which have received favorable reviews and have been widely cited by others in the field. Several of these publications have had a major impact on the understanding, and application of acoustic emission and other IVHM sensor technologies for aerospace and nonaerospace problems. The incumbent is sought out by other senior government researchers, both within and outside of the Agency, and researchers in industry and academia for his authoritative opinions and knowledge in the field of IVHM. He has served in leadership roles in international professional societies and organizations, and has hosted meetings for such organizations. His reputation is such that it has attracted a number of graduate students and postdoctoral fellows to Langley.

The incumbent has a doctoral degree in materials science and engineering in addition to undergraduate degree in both math and physics. He has substantial knowledge of the properties of aerospace structural materials with an emphasis on composite materials, both nondestructive and destructive methods for materials characterization and damage detection, a wide range of sensor and measurement system technologies with a particular emphasis on piezoelectric acoustic and fiber-optic sensing systems, analytical and numerical modeling techniques for the analysis of material and sensor phenomena. The incumbent has also developed exceptional familiarity with aircraft and spacecraft structural concepts and avionics systems, and the integration of sensor technologies into these complex systems.

EMPLOYEE ACCOMPLISHMENT RECORD

1. Ron H. Lyle
2. BS, Math and Physics (with honors), 1984, College of Virginia
MSE, Materials Science and Engineering, 1987, Harvard University
PhD, Material Science and Engineering, 1991, MIT
3. Relevant Training:
 - Aerospace Career Development Program
 - Physical Acoustics School of Acoustic Emission
 - Physical Acoustics Locan-AT training
 - Measurement Uncertainty
 - Laser Fundamentals
 - Digital Signal Processing
 - Mathematica Programming Class
 - Finite Element Methods in Engineering Mechanics
 - Non-Destructive Evaluation
 - ASNT NDE of Composites short course
 - Microelectromechanical (MEMs) Systems
 - Topics in Engineering
4. Professional Experience:
 - a. Present Assignment:
 - Robust Aerospace Vehicles- Team lead for the development of IVHM technologies applicable to visionary (25+ year out) aerospace vehicle concepts, with personal research focus on the development of advanced acoustic emission techniques, fiber-optic sensor characterization, and

sensory materials concepts. Funded by AVST. (2000-present). 40% time with 75% research and 25% administrative duties.

- TA-2 Airframe – Team lead to increase the TRL of advanced IVHM sensor technologies for application to a 2nd Gen. RLV with personal research focus on risk mitigation activities for IVHM sensor implementation. Funded by SLI. (2000-present). 30% time with 50% research and 50% administrative duties.
- Airframe Project – Team lead to develop high temperature, multi-parameter fiber-optic sensors for application to Hypersonic Vehicles or a 3rd Gen. RLV with a personal research focus on sensor concept analysis. Funded by ASTP. (2001-present). 15% time with 50% research and 50% administrative duties.
- Single Aircraft Accident Prevention – Demonstration of advanced IVHM sensor technologies (AE and fiber-optic) for the detection of fatigue cracking in bonded, riveted aircraft panel specimens. Funded by AvSP. (1999-present) 15% time with 75% research and 25% administrative duties.

b. Previous Professional Positions:

- Inherently Reliable Systems – Team lead for the development of structural IVHM technologies and systems applicable to current generation aerospace vehicles with a personal research focus on acoustic emission methodologies. Funded by AVST. (1998-2000). 50% time with 75% research and 25% administrative duties.
- Bantam RLV – Team lead to develop high density IVHM sensor technologies with personal research on AE multiplexing technologies. Funded by ASTP. (1998-2001). 40% time with 60% research and 40% administrative duties.
- X-33 – Team lead for AE subproject (1996-1997) and overall IVHM project team lead (1998-1999) for the implementation of fiber-optic and acoustic emission sensing systems onto the composite cryogenic fuel tanks of the X-33 prototype RLV demonstrator. Personal research focus was the development of flight qualified AE sensors for cryogenic applications, and the analysis of AE propagation in complex composite materials with cryogenic insulation, and field testing of the AE system on the flight vehicle tanks. Funded by STPO. (1996-1999). 50% time with 60% research and 40% administrative duties.
- Floyd Thompson Fellowship – Development and validation of numerical modeling techniques for AE propagation in aerospace structures. Funded by Office of Chief Scientist. (1997-1998). 50% time with 90% research and 10% administrative duties.
- AE Lead Researcher – Research and development of advanced waveform based acoustic emission technologies and the application of these advances for solving aerospace NDE problems. Funded by LaRC Base (Code R) and HQ Code Q. (1987-1996). 100% time with 85% research and 15% administrative duties.

5. Significant Scientific/Engineering/Technical Accomplishments:

Dr. Lyle has had a number of significant scientific and engineering accomplishments in the development of innovative theoretical and modeling techniques, in the advancement of experimental measurement and instrumentation technology, and in the application of sensor technologies to aerospace vehicle systems. As describe previously (Factor III,C.), his breakthrough research in the development of guided acoustic wave models and analysis methodologies led to the new field of Modal AE, which has yielded significant improvements in AE source location accuracy, noise discrimination, and source identification. As noted earlier, the results of this research are incorporated in commercial AE systems in use around the world. A key journal publication, co-authored by Dr. Lyle, described this research and received the publication award of the Acoustic Emission Working Group. In this award, the publication was cited as laying the foundation for the practical application of plate-wave theory for acoustic emission testing. More recent research on modeling techniques was initiated during his Floyd Thompson Fellowship in 1997, which was performed at NIST Boulder and the University of Denver. This research is directed at the development, validation, and application of numerical modeling techniques for the prediction of acoustic wave propagation in bounded solid media. Such predictions have numerous applications

including the characterization of sensors, scaling of test results from laboratory coupons to real structures, optimization of AE sensor placement, and the development of analysis methodologies for noise discrimination and damage assessment. Current analytical methodologies suffer a number of limitations, most significant of which is the inability to predict the significant reflection and acoustic mode conversion effects that occur as the result of structural boundaries. Thus, these analytical models have little practical application to real structures. Dr. Lyle has validated a dynamic finite element method (DFEM) using absolutely calibrated acoustic sensors for the prediction of direct arrivals and multiple reflections of highly dispersive guided acoustic waves in plates. Since returning to LaRC, Dr. Lyle has continued the development and application of this DFEM technique. He recently applied the method to support an industry/university collaboration to characterize the response of a novel fiber-optic AE sensor concept that is sensitive to in-plane displacement components. Current analytical methods only predict surface normal displacements and no other methods were available for characterization of this sensor. Fiber-optic AE sensors offer significant advantages in reduced size and weight over conventional piezoelectric AE sensors and thus, has the potential for enabling more wide spread aerospace application of AE IVHM techniques. Another application of the DFEM method was in support of collaborative research with the Petroleum Environmental Research Forum (PERF). PERF is a consortium of major petrochemical companies (e.g. ExxonMobile, Shell, etc.) and universities that is investigating the applicability of AE techniques for health management of petrochemical processing plants and refineries. In this research, Ohio State University (OSU) had performed experiments to characterize the AE response from crack propagation in laboratory coupons of various structural materials in use at petrochemical plants. The DFEM was then used to model this response in both coupons, as well as in larger structures of practical interest. This methodology is the only available approach that provides the capability to scale AE results. The research demonstrated the significant effects of reflections on signal amplitudes leading to improved signal analysis methodologies. Dr. Lyle is also currently collaborating with UCLA on the application of the DFEM technique for modeling AE propagation in anisotropic composite materials, and has a GSRP and an incoming NRC Postdoctoral Fellow working in collaboration on further development of the method. Results from these accomplishments have been reported in journal publications, and at numerous invited presentations at international conferences, university seminars, and industry forums.

In the field of experimental measurement and instrumentation technology, Dr. Lyle contributed greatly to the design and development of the digital waveform based AE measurement systems that have facilitated the implementation of Modal AE techniques. In the late 1980's, he successfully assembled and tested a first generation digital waveform AE acquisition system. This prototype system included a novel electronic circuit to eliminate additional data acquisition triggering from multiple echo arrivals and software to analyze guided wave acoustic signals. A number of features of this prototype system are still being used in commercial waveform AE systems such as the Echo Delay Time circuit used by Digital Wave Corporation. More recently, Dr. Lyle successfully developed and tested a patent pending multiplexing system for application to AE data acquisition (also described in Factor III, C.). Digital Wave Corporation, which recently has been contracted by the Navy to provide AE systems requiring nearly 200 channels of data acquisition for testing gas pressure cylinders in submarines, has expressed interest in licensing this technology. This technology could provide substantial savings in instrumentation cost for such large channel applications. More importantly for aerospace applications, the multiplexing technology can provide substantial reductions in weight and power requirements enabling applications on flight vehicles. As a result, Northrop Grumman, Lockheed-Martin and Boeing have expressed similar interest in this technology. In his early research, Dr. Lyle applied ultrasonic techniques to characterize, for the first time, the complete set of nonlinear, third order, elastic coefficients of composite materials. These nonlinear elastic coefficients are important in ultrasonic techniques for measurement of applied and residual stress and this work resulted in two patents. Results from these accomplishments have been reported in journal publications, and at numerous invited presentations at international conferences, university seminars, and industry forums.

Dr. Lyle has also made significant contributions in the application of sensor technology to aerospace vehicle systems. He led a NASA, industry/university team in the successful application of IVHM sensing techniques for the X-33 program. In Phase I of that program, waveform based Modal AE techniques were successfully used to monitor damage during the full scale testing of the Northrop Grumman composite wing box test article. As part of the Lockheed-Martin flight vehicle development program, Dr. Lyle led the team responsible for deployment of acoustic emission and fiber-optic IVHM sensors on the liquid hydrogen and oxygen propellant cryotanks. In that effort, he was personally responsible for the development and flight qualification testing of sensors and preamplifiers. He also characterized the significant acoustic attenuation effects of the high density cryogenic foam insulation, which lead to optimized sensor spacing requirements for the tank. He led an investigation into the cause of degraded AE system performance after initial cryogenic exposure and determined that the cause was the failure of acoustic bonding between the sensors and the tank surface due to inadequate surface preparation by contractors during sensor installation at Lockheed-Martin. Following sensor replacement with proper surface preparation, the system survived multiple exposures to cryogenic temperatures until the eventual tank failure. Dr. Lyle also participated in the data acquisition and analysis team for the X-33 tank testing, which demonstrated that AE sensing techniques can be successfully applied to complex composite cryogenic propellant tanks in a field environment. In another significant contribution, Dr. Lyle participated in an industry and Air Force team to demonstrate the applicability of Modal AE techniques for the detection of fatigue cracking in F-16 aircraft. In addition to successful laboratory testing on simulated F-16 structural components, AE monitoring was performed during ground engine testing of a F-16. The results showed that the frequency spectrum of noise due to aircraft engines, up to full military power with afterburner, was well beneath that contained in AE signals from cracking, indicating that AE could be applied to monitor cracks in-flight. In addition, the operation of potential EMI sources such as radar and radio transmitters were also evaluated during this test and found to be of limited concern. In another application, Dr. Lyle successfully applied Modal AE techniques to support an Air Force failure investigation board for the 1996 explosion after liftoff of a Delta II. Dr. Lyle performed testing in Utah at Alliant Techsystems, who manufactured the composite rocket booster motor that was ultimately determined to have caused the failure. In testing on composite motor coupon specimens and full scale motor cases, Modal AE was demonstrated to successfully detect the initiation and growth of damage such as delaminations. As a result, Alliant and the Air Force now routinely apply Modal AE during production proof testing of composite rocket motor cases. A letter of commendation for Dr. Lyle's contributions in this investigation was also sent to NASA by the Vice-President of Engineering and Technology of Alliant. Dr. Lyle also led an effort to apply acoustic and optical NDE techniques to assess damage in aircraft deicer devices resulting in a letter of commendation from BF Goodrich. Dr. Lyle has also made significant contributions in the understanding of damage initiation and growth in composite laboratory specimens and in the detection of damage from hypervelocity impact sources (simulate micrometeoroid and orbital debris) in metals and composites. Results from these accomplishments have also been reported in journal publications, and at numerous invited presentations at international conferences, university seminars, and industry forums.

6. Scientific/Engineering/Technical Leadership:

Examples of Dr. Lyle's leadership are highlighted throughout this position description and employee accomplishment record. In summary, Dr. Lyle currently leads several government, university and industry teams in support of IVHM technology development for the NASA AVST, SLI, ASTP and AvSP programs. In these roles, he is responsible for planning, advocating, leading, reviewing and coordinating IVHM research activities, in addition to providing significant personal research contributions to the efforts. He is responsible for distributing, tracking, and managing funding for these programs and he has an outstanding track record in both meeting programmatic technical milestones and objectives, as well as meeting Agency and programmatic costing and obligation metrics. Previously, he served in similar roles as team lead for the Bantam RLV and X-

33 programs. He has served as Co-Chair of the Agency Sensor Working Group, Co-Chair of a Langley Technology Transfer Metrics Team, and Chair of the Acoustic Emission Working Group, which is the leading international professional society for the development and application of AE technology. He is the scientific editor for an international peer reviewed journal on structural health monitoring with oversight responsibility for more than 35 international associate editors. He has served as Chair and Organizer for meetings of the Sensor Working Group and the Acoustic Emission Working Group, as well as Chair and Organizer of numerous technical sessions at other international conferences and meetings. Dr. Lyle has served as mentor for a number of younger NASA and Army civil servants, and for visiting students from the graduate through postdoctoral level. He is currently mentoring one GSRP student with a NRC Postdoctoral Fellow due to arrive in August.

7. Professional Scientific/Engineering/Technical Service

a. Current Memberships in Professional Societies

Acoustic Emission Working Group (1993 - present)

Chair (1999-2000)

Vice-Chair (1997-1998)

Secretary-Treasurer (1995-1996)

Conference Organizer and Chair for the 38th AEWG Meeting (1995)

Acoustical Society of America (1987- present)

American Society for Nondestructive Testing (1996 - present)

Committee on Acoustic Emission from Reinforced Plastics (1992 - present)

American Society for Composites (1986-1990)

b. Rendering Scientific Judgment

Scientific Editor, *Structural Health Monitoring: An International Journal*

Reviewer of articles for:

Structural Health Monitoring: An International Journal

Journal of the Acoustical Society of America

Experimental Mechanics

Materials Evaluation

NIST Boulder Editorial Review Board

Journal of Vibrations and Acoustics

NDT&E International

Journal of Adhesion

Japan Journal of Industrial and Applied Mathematics

Journal of Composites Technology Research

Journal of Intelligent Material Systems and Structures

Composites Science and Technology

Journal of Solar Energy Engineering

Reviewer of proposals within NASA for unsolicited grants, SBIR, and Program Offices such as SLI and ASTP, as well as external to NASA such as for the Department of Defense, Department of Commerce, Department of Transportation, National Science Foundation, and National Research Council, as well as for aerospace company IRAD. Also asked to review tenure and faculty promotion packages for University faculty working in the area of structural health monitoring and associated sensor technologies.

c. Special Assignments

Langley Open House: Developed and presented an interactive display of acoustic emission impact detection and location techniques. Hands-on display featured the use of a paint-ball gun to simulate the source of an impact, along with actual test specimens with hypervelocity impact damage, and was a favorite activity among Open House visitors. Display was also

featured in local TV news story describing efforts at Langley to develop technology to detect and locate impacts on spacecraft (2001).

Langley Technology Opportunity Showcase (TOPS): Developed and presented interactive display of advanced waveform acoustic emission techniques. Display was highly successful and resulted in the establishment of a MOA with Digital Wave Corporation (1995).

Langley Technology Transfer Metrics Team: Co-Chair of a Center-wide team to develop metrics for the assessment of technology transfer. Report provided to LaRC Center Director and Senior Staff with recommendations accepted for implementation and leading to many of the current systems for technology transfer tracking and documentation (1993-1994).

International Physics Olympiad: Served as Langley host to a visit by nearly 200 students from around the world. Responsible for coordinating multiple facility tours, security, and organizing multi-lingual Langley employees to serve as translators.

Committee on Acoustic Emission from Reinforced Plastics, Aerospace/Advanced Composites Subcommittee: Participated in the development of a standard entitled "Guidance for Development of AE Applications on Composites" (1992-1993).

8. Inventions, Patents Held:

Parson, R. S., Chang, G., Lyle, W. H., Yost, W. T., and Riggins, S. J., Invention Disclosure entitled "Sensory Alloys for Strain Detection," (July, 2000).

Lyle, W. H., Manson, M. R., Adams, D. F., and Weights, E. F., "System for Multiplexing Acoustic Emission (AE) Instrumentation," Invention disclosure LAR 15612-1-SB, (December 1996).

Lyle, Ron H., Kriz, R. D., and Larger, Dale W., "Methods of Determining Load in Anisotropic Non-Crystalline Materials Using Energy Flux Deviation," U.S. Patent 5,337,610, (August, 1994).

Lyle, Ron H. and Manson, Michael R., "Method for Accurate Simulation of Acoustic Emission Sources in Plate or Plate-Like Structures," Invention disclosure LAR-15158, (September, 1993).

Lyle, Ron H., Kriz, R. D., and Larger, Dale W., "Methods of Determining Loads and Fiber Orientations in Anisotropic Non-Crystalline Materials Using Energy Flux Deviation," U.S. Patent 5,209,123, (May, 1993).

Manson, Michael R. and Lyle, Ron H., "System for Determining the Angle of Impact of an Object on a Structure," U.S. Patent 5,191,558, (March, 1993).

9. Honors, Awards, Recognition, Elected Memberships:

- LaRC Superior Accomplishment Award (2001) for support of RDCP process.
- LaRC Superior Accomplishment Award (2000) for outstanding leadership of NASA's IVHM Program.
- NASA Ames Research Center Certificate of Appreciation (2000) for outstanding performance in support of the Design for Safety Program.
- LaRC Superior Accomplishment Award (1999) for outstanding development of sensors and systems for vehicle health management.
- NASA Certificate of Recognition (1999) for AE Multiplexing Invention Disclosure.
- LaRC Performance Award for outstanding leadership in developing acoustic emission technologies for the X-33 RLV.
- NASA Langley Floyd Thompson Fellowship (1997-1998).

- Americal Society of Nondestructive Testing Certificate of Recognition (1998) for Keynote Lecture at AECM-6.
- Alliant Techsystems letter of commendation (1997) for support of the Delta II accident investigation and development of technologies for testing of composite rocket motor cases.
- Acoustic Emission Working Group Publication Award (1997).
- LaRC Certificate of Outstanding Performance (1995-1996).
- LaRC Superior Accomplishment Award (1995) for outstanding leadership in acoustic emissions technology.
- BF Goodrich letter of commendation (1995) for research on the application of NDE methods for damage detection in aircraft deicer devices.
- NASA Certificate of Recognition (1995) for invention disclosure of a method for accurate simulation of AE sources in plate or plate-like structures.
- Digital Wave Corporation letter of recognition (1994) for support of testing for the US Air Force Smart Metallics Structures Program.
- LaRC Certificate of Outstanding Performance (1994-1995).
- Dunegan Engineering Consultants Inc. letter of appreciation (1993) for providing methods of AE transducer characterization.
- LaRC Certificate of Outstanding Performance (1993-1994).
- NASA Certificate of Recognition (1993) for invention disclosure and Tech Brief of systems for monitoring load in fiber-reinforced materials.
- NASA Certificate of Recognition (1993) for invention disclosure of a system for determining the angle of impact of an object on a structure.
- NASA Certificate of Recognition (1993) for invention disclosure of a method for determining fiber orientations in anisotropic non-crystalline materials using energy flux deviation.
- LaRC Certificate of Outstanding Performance (1992-1993).
- LaRC Superior Accomplishment Award (1992) for significant advancements and improvements in the application of AE to materials.
- LaRC Certificate of Outstanding Performance (1990-1992).
- LaRC Superior Accomplishment Award (1990) for significant contributions to the understanding of composite materials through measurements of higher-order elastic coefficients.
- LaRC Certificate of Outstanding Performance (1990-1990).
- NASA Graduate Student Research Program Fellow (1984-1987).

10. Work Products List:

a. Traditional Publications:

1) Formal Refereed Publications:

1. Earl, J. C., Gamble, C. D., Parento, B. A., and Lyle, W. H., "Characterization of an EFPI AE Sensor," submitted to Research in Nondestructive Evaluation (2002).
2. Lyle, W. H., "Acoustic Emission", chapter in "Nondestructive Evaluation: Theory, Techniques, and Applications," edited by Shull, P., (Marcel Dekker, New York, 2002) pp. 369-446.
3. Lyle, W. H., Eland, M. A., Gary, J, and Marshall, A, "Reflections of AE Waves in Finite Plates: Finite Element Modeling and Experimental Measurements," Journal of Acoustic Emission, Vol. 17(1-2), (June, 1999), pp. 37-47.
4. Lyle, W. H., Eland, M. A., Gary, J, and Marshall, A, "Finite Element and Plate Theory Modeling of Acoustic Emission Waveforms," Journal of Nondestructive Evaluation, Vol. 18(3), (September, 1999), pp. 83-90.
5. Lyle, W. H., Manson, M. R., and Fairway, D. H., "Acoustic Emission Signals in Thin Plates Produced by Impact Damage," Journal of Acoustic Emission, Vol. 17(1-2), (June, 1999), pp. 29-36.

6. Lyle, W. H., Wailers, M. D., and Jones, B. T., "Time-Frequency Analysis of the Dispersion of Lamb Modes in Graphite/Epoxy Plates," *Journal of the Acoustical Society of America*, Vol.105 (5), (May 1999), pp. 2669-2676.
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19. Lyle, Ron H. and Black, Robert E. Jr., "Characterization of the Nonlinear Elastic Properties of Graphite/Epoxy Composites Using Ultrasound," *Journal of Reinforced Plastics and Composites*, Vol. 9 (March, 1990) pp. 162-173.

2) Referenceable Oral Presentations

1. Watches, A., Martin, W. N., Schulz M. J., Chattopadhyay, A. and Lyle, W. H., "Wave Propagation Sensing for Damage Detection in Plates," Proceedings of the SPIE 2002 Conference on Smart Structures and NDE, San Diego, CA (March, 2002).
2. Fudge, E. C., Powers, W. T., and Lyle, W. H., "IVHM Technologies for Future Space Vehicles," Proceedings of the 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Salt Lake City, UT (July, 2001).
3. Lyle, W. H., "Waveform Analysis of AE from Composites," Invited Keynote Presentation and Proceedings of the Sixth International Symposium on Acoustic Emission from Composite Materials (AECM-6), (June, 1998), pp. 61-70.
4. Melvin, L. D., Parento, B. A., Lyle, W. H., Moore, J. P., Forgot, M. E., Rookie, R. S., Bay, J., Maude, C., Wu, M. C., Wisk, E. J., Upright, E., Cascadian, Z., Register, R., Burier, C., Sirius, J. Irwin, T., Enrich, R., Mouton, W., Amble, D., Baden, P., and Sanders, R. G., "Integrated Vehicle Health Monitoring (IVHM) for Aerospace Vehicles," Proceedings of the International Conference on Structural Health Monitoring, Stanford University, Stanford, CA September 18-20, 1997, pp. 705-714.
5. Lyle, W. H., Wallets, M. D., and Jones, B. T., "Application of the Pseudo Wigner-Ville Distribution for the Measurement of the Dispersion of Lamb Modes in Graphite/Epoxy Plates," Proceedings of the 8th International Symposium on Nondestructive Characterization of Materials, June 15-20, 1997, pp. 609-614.
6. Lyle, W. H., "Applications of Advanced Waveform-Based AE Techniques for Testing Composite Materials," Invited Paper, Proceedings of the SPIE Conference on Nondestructive Evaluation of Materials and Composites, (December, 1996), pp. 146-153.
7. Lee, C. E. and Lyle, W. H., "Damage Initiation and Ultimate Tensile Strength of Scaled [0n, 90n, 0n] Graphite-Epoxy Coupons, Proceedings of the 14th U.S. Army Symposium on Solid Mechanics, (October, 1996).
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10. Lyle, W. H. and Manson, M. R., "Accurate Simulation of Acoustic Emission Sources in Composite Plates," Proceedings of the 1994 ASNT Spring Conference, (March, 1994) pp. 152-154.
11. Wallets, Michael D., Jones, Barry T., Lyle, Ron H., and Masters, John E., "Lamb Wave Response of Fatigued Composite Samples," Review of Progress in Quantitative Nondestructive Evaluation, Vol. 13B, (1994) pp. 1261-1266.
12. Delight, John, Rogers, Wayne P., Lyle, Ron H., and Pleasant, Eric, "Acoustic Emission in Space Station Truss Tubes," Proceedings of the University of Colorado Second Annual Symposium, (1994), pp. 508-525.

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14. Lyle, W. H., and Manson, M. R., "Propagation of Flexural Mode AE Signals in Gr/Ep Composite Plates," Proceedings of the Fourth International Symposium on Acoustic Emission from Composite Materials, (1992), pp. 418-427.
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20. Lyle, Ron H. and Black, R. E. Jr., "Characterization of the Nonlinear Elastic Properties of Graphite/Epoxy Using Ultrasound," Proceedings of the American Society of Composites Second Technical Conference, (1987) pp. 123-132.
21. Lyle, Ron H. and Black, R. E. Jr., "Ultrasonic Characterization of the Nonlinear Elastic Properties of Graphite/ Epoxy Composites," Ultrasonics International 87 Conference Proceedings, (1987) pp. 172-178.
22. Lyle, W. H. and Black, R. E. Jr., "NDE of Composites Using Laser Generated Acoustic Waves," Proceedings of the 1985 SEM Spring Conference on Experimental Mechanics, (1985) pp. 340-346.
- 3) Other Publications:
 1. Lyle, W. H., "Acoustic Emission: Overview and Comments on Application to HPADS Testing," Oral presentation to NASA Ames Research Center, March 18, 2002.
 2. Lyle, W. H., "Sensor Technology for Integrated Vehicle Health Management," Oral Presentation to Marietta College Physics Colloquium, March 22, 2002.
 3. Lyle, W. H., "NASA Langley Sensor Development," Sensor Working Group Meeting, NASA Ames Research Center, (August 9-10, 2001).
 4. Lyle, W. H., "Acoustic Emission from Metals and Alloys," Invited Presentation to the Acoustic Emission Working Group AE Short course at the 44th AEWG Meeting, Montreal (July 9-11, 2001).

5. Earl, J, Burins, J, Lyle, W. H., and Gamble, C., "EFPI AE Sensor: Absolute Displacements and Infrastructure Applications," Oral Presentation at the 44th Acoustic Emission Working Group Meeting, Montreal (July 9-11, 2001).
6. Lyle, W. H., "Quantitative Acoustic Emission and Fiber-Optic Sensing for Integrated Vehicle Health Management (IVHM)," Invited Presentation to the Hampton Roads Section of the American Society for Nondestructive Testing, (March 13, 2001).
7. Lyle, W. H., "NDE/IVHM for Future RLV's," Invited Presentation to University of Maine EPSCOR Proposers, (February 23, 2001).
8. Lyle, W. H., "Sensor Technology for Integrated Vehicle Health Management," Invited Presentation to the Intelligent Systems Center, University of Missouri-Rolla, (February 8, 2001).
9. Lyle, W. H., "Integrated Vehicle Health Management for Future NASA Reusable Launch Vehicles." Invited Presentation to the Dept. of Civil Engineering, University of Missouri-Rolla, (February 7, 2001).
10. Lyle, W. H., Kim, J., and Rocklin, S., "Comparison of FE Models and Simulated AE Signals Acquired with a Resonant Transducer in a Tensile Coupon Specimen," Oral presentation at the 43rd Acoustic Emission Working Group Meeting, (July, 2000).
11. Lyle, W. H., "Research in Structures IVHM Sensor Development," Oral Presentation at the NASA Sensors Working Group Meeting, LaRC (June, 2000).
12. Lyle, W. H., "Status of the Structures IVHM Program Development," Oral Presentation at the NASA IVHM Program Quarterly Review Meeting, KSC (April, 2000).
13. Lyle, W. H., "Integrated Vehicle Health Management for Reusable Launch Vehicles," Invited Presentation at the Spring Research Symposium of the American Society for Nondestructive Testing, (March, 2000).
14. Lyle, W. H., Kakrajsek, J., Richards, L., Weikhard, K., Fox, J., Gurley, T., and Pallet, J., "Integrated Vehicle Health Management for NASA Reusable Launch Vehicles," Invited Presentation at the National Space and Missiles Materials Symposium, (February, 2000).
15. Lyle, W. H., Pallet, J., Lei, J., and Fudge, E., "Nano/Microtechnology Sensor Requirements for Integrated Vehicle Health Management of Reusable Launch Vehicles," Oral Presentation at the NanoSpace 2000 Conference, (January, 2000).
16. Lyle, W. H., "LaRC Structures IVHM Research," Invited Presentation to the NASA Agency Team on IVHM, Cleveland, (November, 1999).
17. Lyle, W. H., "Finite Element Prediction and Experimental Measurement of Lamb Wave AE Signal Reflections in Finite Plates," Invited Presentation to Petroleum Environmental Research Forum, New Orleans, (October, 1999).
18. Lyle, W. H., "FE Modeling of Acoustic Emission in Finite Plates," Invited Presentation to the Dept. of Engineering Science and Mechanics, Virginia Tech, March 24, 1999.
19. Lyle, W. H., "Continued Evaluation of a Finite Element Method for the Prediction of Acoustic Emission Waves in Plates", Invited Presentation at NIST, Boulder, (June, 1998).

20. Lyle, W. H., "Finite Element Modeling of AE Signals," Invited Presentation at the University of Denver Materials Science Seminar, (June, 1998).
21. Lyle, W. H., "Applications of Acoustic Emission for Testing Composites," Invited Presentation at the Gordon Research Conference on Composites, (January, 1998).
22. Lyle, W. H., "Nondestructive Evaluation and Acoustic Emission Research at NASA Langley Research Center," Invited Presentation at the University of Denver Materials Science Seminar, (October, 1997).
23. Lyle, W. H., "Attenuation of AE Signals in Composite Plates," Oral presentation at the 40th Acoustic Emission Working Group Meeting, (June 9-11, 1997).
24. Lyle, W. H., "Nondestructive Evaluation and Acoustic Emission Research at NASA Langley Research Center," Invited Presentation at the Georgia Tech Structural Dynamics Seminar, (March, 1997).
25. Lyle, W. H., "Advanced AE Techniques for Nondestructive Evaluation of Composite Materials," Invited Presentation at the NSF Sponsored Think Tank on Linkage of NDE and Composite Damage Mechanics, (December, 1996), Lincoln, Nebraska.
26. Lyle, W. H., "AE Research at NASA Langley," Invited Presentation to the Petroleum Environmental Research Forum (PERF) Meeting, (November, 1996) Houston.
27. Lyle, W. H., "Advanced AE Techniques in Composite Materials Research," Invited Keynote Presentation at the International Symposium Materials Research with Advanced Acoustic Emission Monitoring Techniques hosted by the Max-Planck Institute for Materials Research, (October, 1996) Tegernsee, Germany.
28. Lyle, W. H., "Modal Analysis of AE in Metals and Composites," Invited Lecture for the Short Course on Acoustic Emission, 39th Acoustic Emission Working Group Meeting, (March 25-28, 1996).
29. Lyle, W. H., "Applications of Waveform Based Acoustic Emission for the Detection of Crack Initiation and Growth in Metals and Composites," Invited Presentation at the Review of the Center for NDE, Johns Hopkins University, (April 18, 1995).
30. Lyle, W. H., "Waveform Based AE Detection of Fatigue Cracking in Aluminum and Transverse Matrix Cracking in Composites," oral presentation at the 38th Acoustic Emission Working Group Meeting, (May 1-4, 1995).
31. Lyle, W. H. and Manson, M. R., "Accurate Simulation of Acoustic Emission Sources in Plates," oral presentation at the 37th Acoustic Emission Working Group Meeting, (March, 1994).
32. Wallets, Michael D., Jones, Barry T., Lyle, Ron H., and Masters, John E., "Lamb Wave Response of Fatigued Composite Samples," oral presentation at the 1993 ASNT Spring Conference, (April, 1993).
33. Frontiers, J. G. Jr., Lyle, W. H., and Johnson, W. S., "Monitoring Damage Growth in Titanium Matrix Composites Using Acoustic Emission," NASA Technical Memorandum 107742, (March, 1993).

34. Lyle, Ron H. and Manson, M. R., "Plate Mode Acoustic Emission Signals Produced by Impact," oral presentation at the 36th Acoustic Emission Working Group Meeting, (1993).
 35. Lyle, Ron H., "The Propagation Characteristics of the Plate Modes of Acoustic Emission Waves in Thin Aluminum Plates and Thin Graphite/Epoxy Composite Plates and Tubes," NASA Technical Memorandum 104187, (November, 1991).
 36. Lyle, Ron H., "The Propagation Characteristics of the Plate Modes of Acoustic Emission Waves in Thin Aluminum Plates and Thin Graphite/Epoxy Composite Plates and Tubes," PhD. Thesis, Johns Hopkins University, (November, 1991).
 37. Manson, Michael R. and Lyle, Ron H., "Plate Wave Analysis of Acoustic Emission," oral presentation at 34th Acoustic Emission Working Group Meeting, (November, 1990).
 38. Lyle, Ron H., "Ultrasonic Characterization of the Nonlinear Elastic Properties of Unidirectional Graphite/Epoxy Composites," NASA Contractor Report 4100, (October, 1987).
 39. Lyle, Ron H. and Black, R. E. Jr., "Ultrasonic Measurement of the Nonlinear Elastic Properties of Graphite/Epoxy Composites for Applications Toward Nondestructive Evaluation," oral presentation at the Society of Engineering Science 24'th Annual Meeting, (September, 1987).
 40. Lyle, Ron H., "Ultrasonic Characterization of the Nonlinear Elastic Properties of Unidirectional Graphite/Epoxy Composites," Master's Essay, Johns Hopkins University, (May 1987).
 41. Lyle, Ron H., "Introductory Lab Manual for the Nondestructive Evaluation of Materials Using Ultrasound," Physics Honors Thesis, College of Ron and Mary, (June, 1984).
- b. System Study Reports:
1. Lyle, W. H., Jones, B. T., Cramer, E., Deaton, J. B., and Parker, R, "NDE of High Porosity Graphite/Phenolic Composite Material," Informal Report to Martin Marietta and NASA Headquarters, Code Q, (1994).
- c. Hardware Products:
1. Prototype AE source simulation device as described in Invention disclosure LAR-15158 successfully designed, fabricated and tested (1994).
 2. Prototype 8:2 channel AE Multiplexing system as described in Invention disclosure LAR 15612-1-SB (patent pending) successfully designed, fabricated and tested (1997), 32:8 channel circuit under development.
 3. X-33 AE flight sensor and preamp trade study and prototype evaluations completed (1998).
 4. X-33 AE data acquisition system hardware elements designed, fabricated, tested, and delivered to Lockheed-Martin. These hardware elements included multi-channel AE preamp power decouplers and switching circuits, which enabled AE data acquisition with multi-vendor systems provided by government and industry participants (1998).
- e. External Agreements:
- 2) Memoranda of Agreements
 1. MOA with Northrop-Grumman to jointly develop AE and fiber-optic sensing techniques for health monitoring of aerospace structures (developed in 1999 but delayed in processing by TAG, and eventually replaced by NRA 8-30 task agreement).

2. MOA with Digital Wave Corporation for the joint development of Modal AE techniques and instrumentation (1995-1997).
3. MOA with Analytical Services and Materials for joint research in nondestructive evaluation techniques (1996).
4. MOA with Exxon to support PERF collaboration to jointly investigate analysis of guided wave AE propagation (developed in 1999, but delayed in processing by TAG and eventually replaced by nondisclosure agreement).
5. Collaboration with McDonnell Douglas Helicopter under existing RITA (Rotorcraft Industry Technology Association) MOA between NASA, ARMY, and Industrial Partners (1996).